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Westcountry Rivers Trust

Upper Wotton Brook Catchment Study

Part of Lympstone Flood Risk Management Project

Phase 2 Report

for

Lympstone Parish Council

May 2019

Funded by the Parishes Together Fund
from Devon County Council and East Devon District Council

Devon County Council

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Thanks also to Lympstone Flood Resilience Group, Woodbury Parish Council, and other members of the Steering Group of the Lympstone Flood Risk Management Project, including representatives of the Environment Agency, Devon County Council, East Devon District Council, and South West Water.

EXECUTIVE SUMMARY

This report documents the findings of Phase 2 of the Upper Wotton Brook Catchment Study, which forms part of the Lympstone Flood Risk Management Project. The aim of the study is to understand the contribution of surface water runoff from the upper Wotton Brook catchment (in Lympstone and Woodbury Parishes) to the flood risk in Lympstone, and to identify opportunities for natural flood management (NFM) interventions. Importantly, it will help inform and validate the Environment Agency's hydraulic model for Lympstone (currently being developed).

The study includes three phases:

- Phase 1 – Engaging with landowners and managers, and reviewing current land use and key characteristics of the catchment (to enable an initial assessment of risks and opportunities for NFM).
- Phase 2 – Observing runoff pathways during significant rainfall events, and investigating risks and opportunities identified in Phase 1.
- Phase 3 - Designing and conducting a soil survey to determine the extent and location of any soil structural degradation in the upper catchment.

The first two phases have been funded by the *Parishes Together Fund* from Devon County Council and East Devon District Council (2017 and 2018 funds, respectively). Phase 3 is being funded by the Councils' *Communities Together Fund*.

Phase 2 of the study has provided valuable information on the surface water runoff pathways, the key factors contributing to runoff, and potential NFM interventions.

The runoff pathways observed during four rainfall events (on 29 November 2018, 15 & 17 December 2018, and 6 March 2019) are presented on four maps using the Environment Agency surface water flood map as a base (covering the north, central, south, and west areas of upper Wotton Brook catchment, respectively). These show that although the observed runoff pathways generally reflect the Environment Agency's existing flood map, the map underestimates the runoff from agricultural land, highways and tracks.

Further investigation of the issues that could be contributing to runoff proved useful. The observations show that the increased runoff from arable land (particularly maize fields), and some grass land, is most likely due to soil damage (compaction and capping). Highways and tracks collect runoff from various sources and distribute it rapidly to watercourses and across land. However, the contribution of the solar farm is still not certain (full access to the site was not possible during Phase 2 but is being sought for Phase 3; observations below the site showed no direct overland flows, but there is an intermittent watercourse that appears to be fed by springs or subsurface drainage).

Overall, the observations during Phase 2 highlight several potential NFM interventions, relating to soil management, temporary storage of surface water, and drainage management. These are discussed in the report. However, completion of the soil survey (Phase 3) and the hydraulic model are needed to confirm the scale of interventions required, and their cost-effectiveness. Consultation and agreement with landowners/managers and other relevant stakeholders are also essential. Recommended next steps are presented in the report.

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1 INTRODUCTION

1.1 Background

The Upper Wotton Brook Catchment Study is a key part of the Lympstone Flood Risk Management Project [(1)]. The aim of the study is to understand the contribution of surface water runoff from the rural upper catchment in Lympstone and Woodbury parishes to the flood risk in Lympstone, and to identify opportunities for natural flood management (see box below). Importantly, it will help inform and validate the Environment Agency's hydraulic model for Lympstone (currently being developed).

Natural flood management (NFM)
NFM involves implementing a range of land management interventions to slow the rate of flow and store more flood water in the upstream catchment. These interventions are varied depending on the local situation, and can include, for example, improving soil structure, diverting water away from tracks, and establishing flood storage areas.

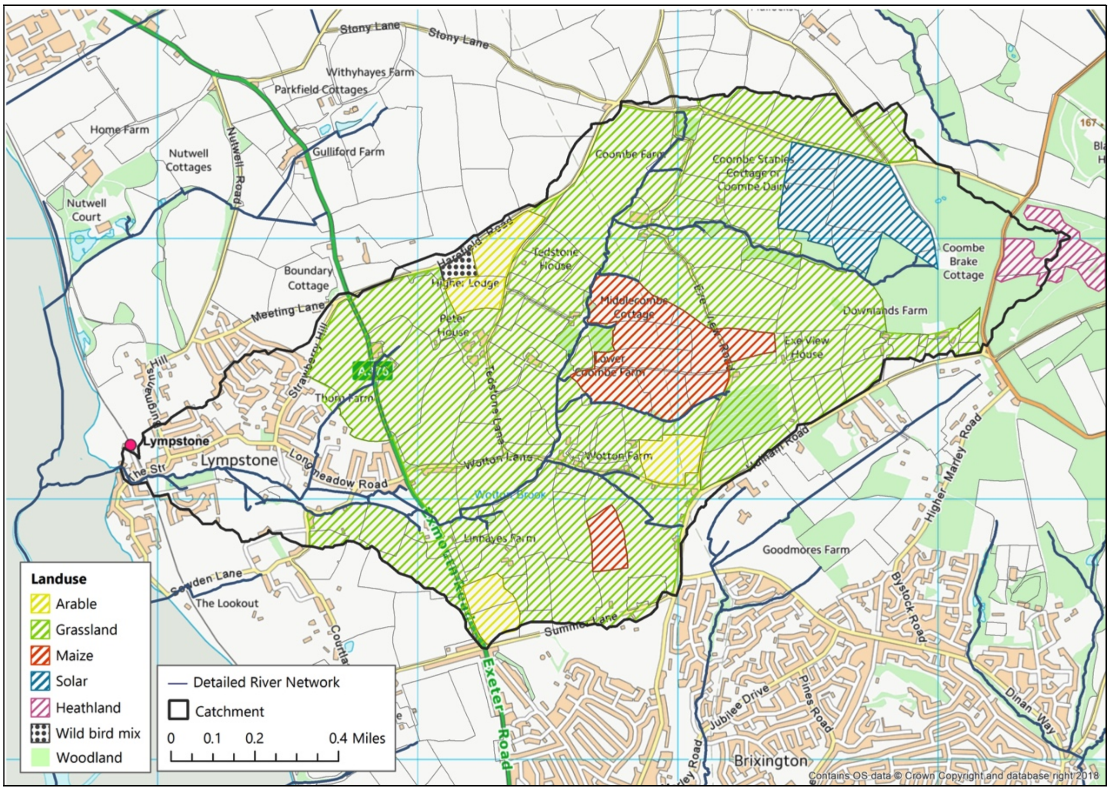
The study initially comprised two phases (funded by the *Parishes Together Fund* from Devon County Council and East Devon District Council), but funding for an important third phase of work has since been secured from the *Communities Together Fund*. These phases include:

- Phase 1 – Engaging with landowners and managers, and reviewing current land use and key characteristics of the catchment (to enable an initial assessment of risks and opportunities for NFM).
- Phase 2 – Observing runoff pathways during significant rainfall events, and investigating risks and opportunities identified in Phase 1.
- Phase 3 – Designing and conducting a soil survey to determine the extent and location of any soil structural degradation (which can have a significant impact on runoff and flood risk).

Phase 1 was completed in 2018 (see report dated September 2018). There was positive engagement with land managers, and this proved very helpful in understanding the catchment and current land use practices (Map 1). Several issues were identified that could be contributing to the flood risk, including farming practices which can damage the soil structure (maize and other arable cropping, livestock grazing and other grassland operations), highway and track drainage, and potential runoff from a solar farm. However, Phase 1 of the study was completed at the end of the long, dry summer of 2018 so there was limited opportunity to observe runoff pathways. This is the purpose of Phase 2, described more in Section 1.2 and the subject of this report, while Phase 3 (to be completed in the winter 2019/20) will investigate the condition of the soil in more detail.

(1) The Lympstone Flood Risk Management Project was established in early 2018 and is led by Lympstone Flood Resilience Group. It is a partnership approach involving all of the Local Flood Risk Management Authorities (Environment Agency, Devon County Council, East Devon District Council, and South West Water plc) and Woodbury Parish Council.

Map 1 – Land use in the upper Wotton Brook catchment (August 2018)



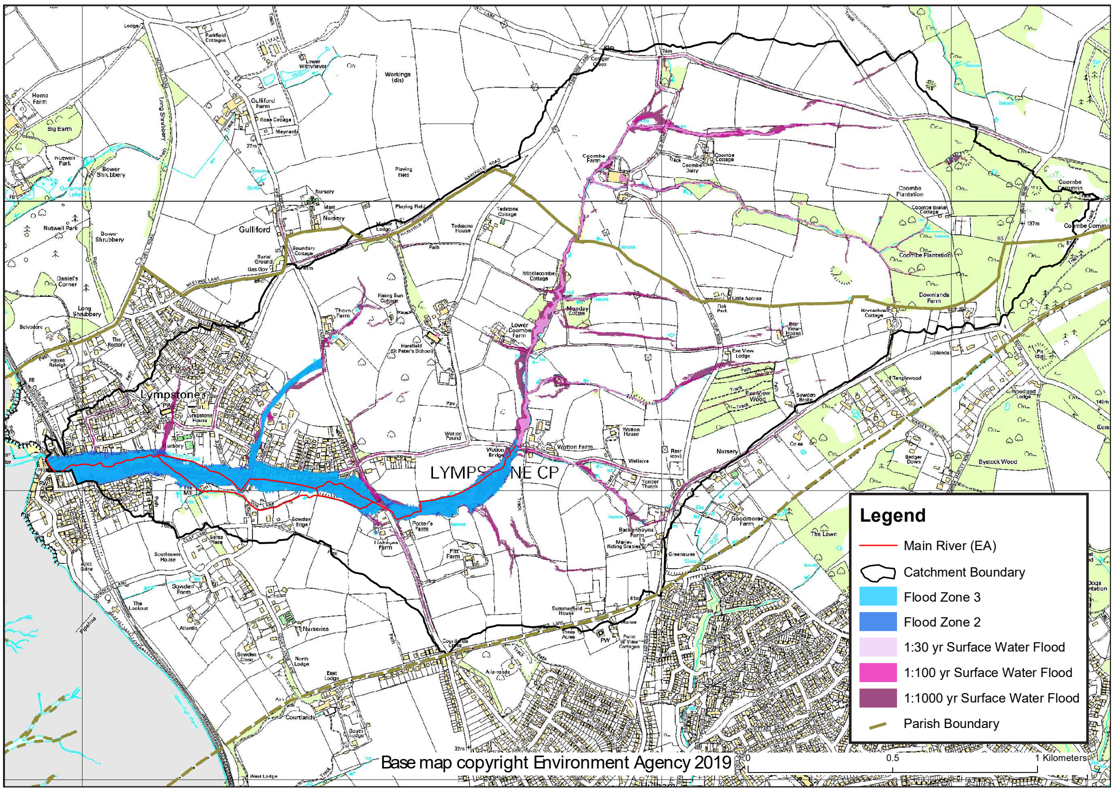
1.2 Purpose and scope

The purpose of Phase 2 is to observe the runoff pathways in the upper Wotton Brook catchment during significant rainfall events, and to further explore the risks and opportunities identified during Phase 1.

Identifying and understanding runoff pathways is key to assessing flood risk and to determining appropriate interventions. This follows the ‘source-pathway-receptor-impact’ approach that is a well-established framework for flood risk assessment.

The Environment Agency has produced surface water flood maps for England and Wales, and the existing map for the Wotton Brook catchment (Map 2) has been used as a base for comparison during this study. The Agency’s maps are developed using computer models that take local topography and weather patterns into account. These are very useful but clearly have their limitations. The outputs of Phase 2 of this study will help to ground-truth the maps and assist in the development of a more accurate hydraulic model for Lympstone. Consequently, this will help to determine the most appropriate and effective interventions to reduce the flood risk.

Map 2 – Environment Agency flood map for surface water for the Wotton Brook catchment



1.3 Approach

The approach for Phase 2 has involved:

- Inspection of the upper catchment area during significant rainfall events during the winter 2018/19, specifically on: 29 November 2018, 15 December 2018, 17 December 2018, and 6 March 2019.

- Further discussions with key landowners and tenants to learn from their experience of runoff pathways.

Autumn and Winter 2018/19 followed a long, dry summer and much of the period was relatively dry with only a few spells of prolonged wet weather. This reduced the potential to capture relevant information; however, there were sufficient flows across the landscape to determine key pathways and to make a preliminary assessment of potential interventions.

2 OBSERVATIONS OF RUNOFF PATHWAYS

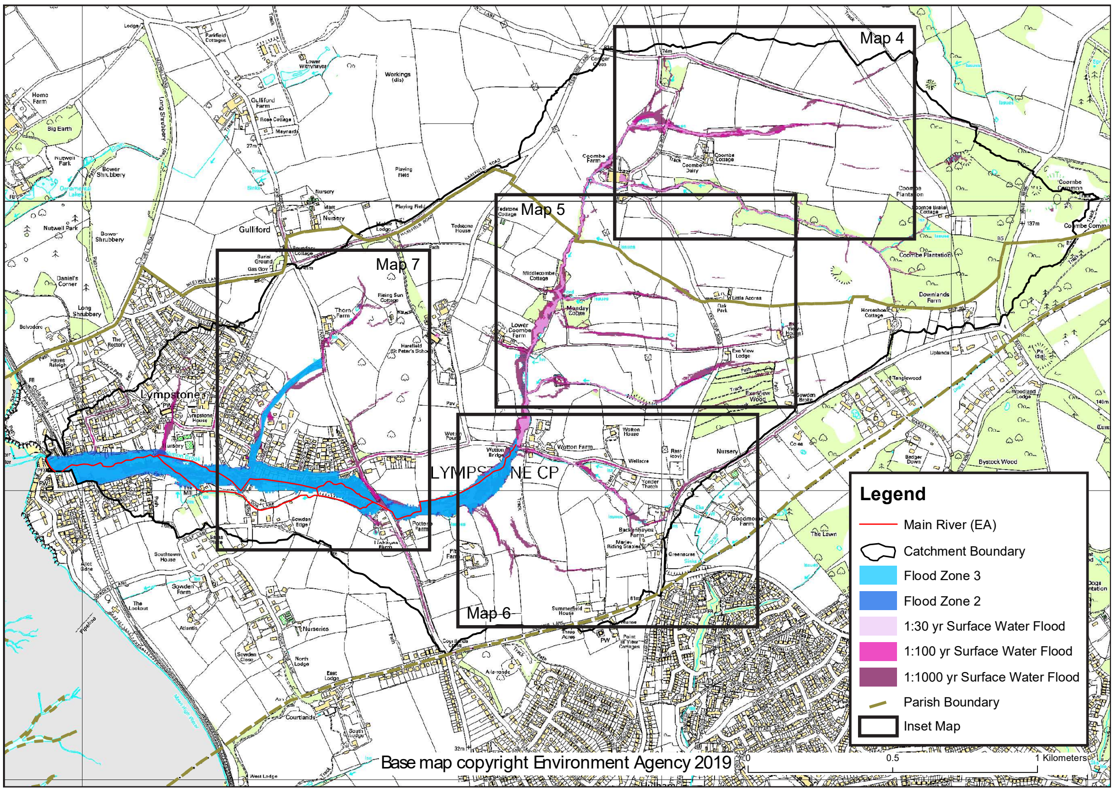
2.1 Overview

In this section of the report, the runoff pathways observed during four rainfall events (on 29 November 2018, 15 & 17 December 2018, and 6 March 2019) are presented on four maps using the Environment Agency surface water flood map as a base. These cover the north, central, south, and west areas of upper Wotton Brook catchment, as shown in Map 3 below. Each map is presented and discussed in sections 2.2 to 2.4, respectively, with photographs to illustrate the runoff pathways.

In summary, the observations to some extent reflect the Environment Agency's existing surface water flood map for Wotton Brook catchment. However, they highlight that the existing map underestimates the runoff from agricultural land (particularly maize and other arable land) and from highways and tracks, and underestimates the frequency of surface water flooding.

It is important to remember that the winter of 2018/19 was relatively benign and followed a dry summer. The Wotton Brook mainly remained within its banks and there were limited flooding concerns. This means that the scale and frequency of surface water runoff could be significantly higher in years with more intensive and/or persistent rainfall.

Map 3 – Overview of maps of observed pathways
(using the Environment Agency surface water flood map as a base)



2.2 North catchment area (Map 4)

North of Coombe Farm, this area is largely grassland with some woodland and a 40 acre photovoltaic solar farm.

The observations indicate that the pathways shown on the Environment Agency flood map are largely accurate, but the frequency of runoff appears to be considerably higher than shown. The land receives drainage from woodland into an easterly tributary, overland from the area of the solar farm, and via the highway (Stony Lane) to the crossroads with Exe View Road (including some flows from outside of the catchment).

Map 4 – Observed pathways in north catchment area

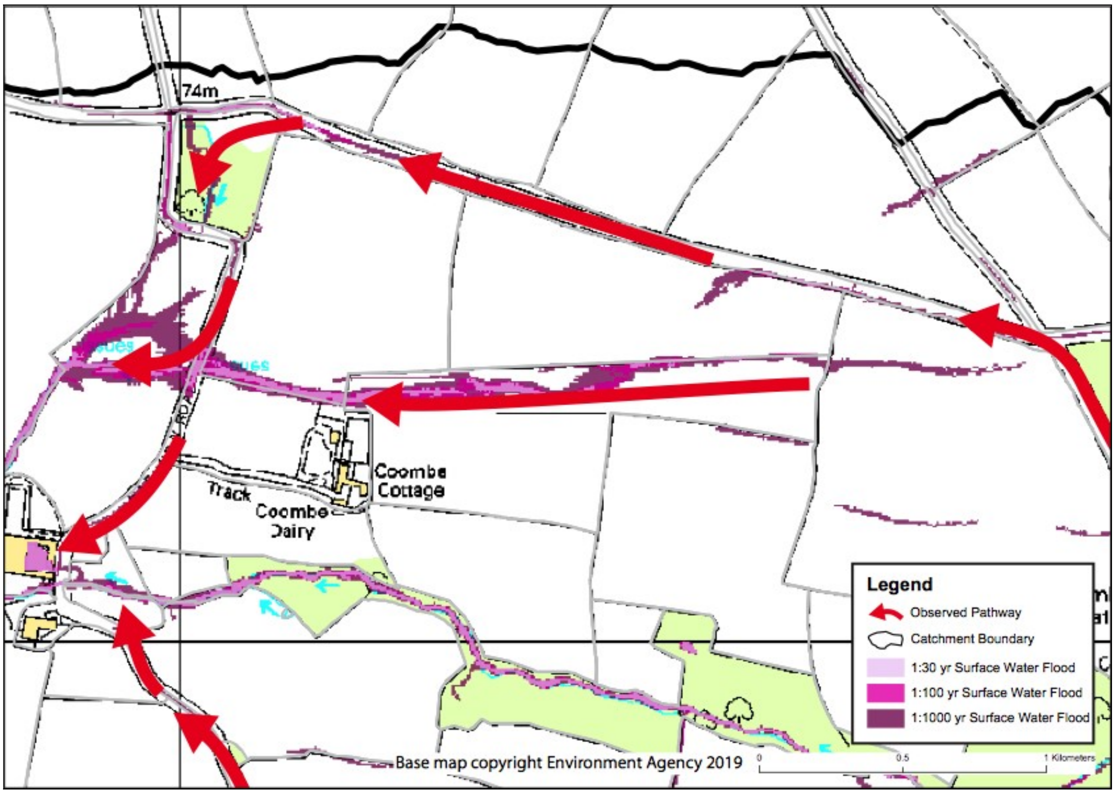


Photo 1 – Run-off along Stoney Lane

Runoff from outside the catchment (Woodbury Common) is partly diverted along Stoney Lane and travels rapidly along the highway to enter the Wotton Brook catchment near the crossroads with Exe View Road.

Photo 2 – Goyle containing runoff from Stoney Lane

The surface water runoff flows along Stoney Lane and in roadside ditches before entering a tributary of the Wotton Brook in a wooded goyle near the crossroads with Exe View Road. Some natural flow detention is therefore provided here.

Photo 3 – Runoff entering Exe View Road

The land above the goyle drains southwards to join with overland flows from the solar farm area resulting in periodic flooding of Exe View Road and the adjacent fields north of Coombe Farm. This road was impassable to normal traffic later on 17 December 2018.

2.3 Central catchment area (Map 5)

This area covers most of the mid section of the catchment to the east of Lower Coombe Farm. Much of the land was used for growing maize during 2018.

In comparison with the Environment Agency flood map, the observations showed considerable additional runoff from arable land (the largest area of maize in the catchment) and woodland east of Exe View Road, often draining onto the highway and subsequently leaving via field or track gateways. This contributed to ponding of water and runoff in the wheelings on arable land. Some of this water also flowed northwards down the highway to enter the Brook higher upstream.

Map 5 – Observed pathways in central catchment area

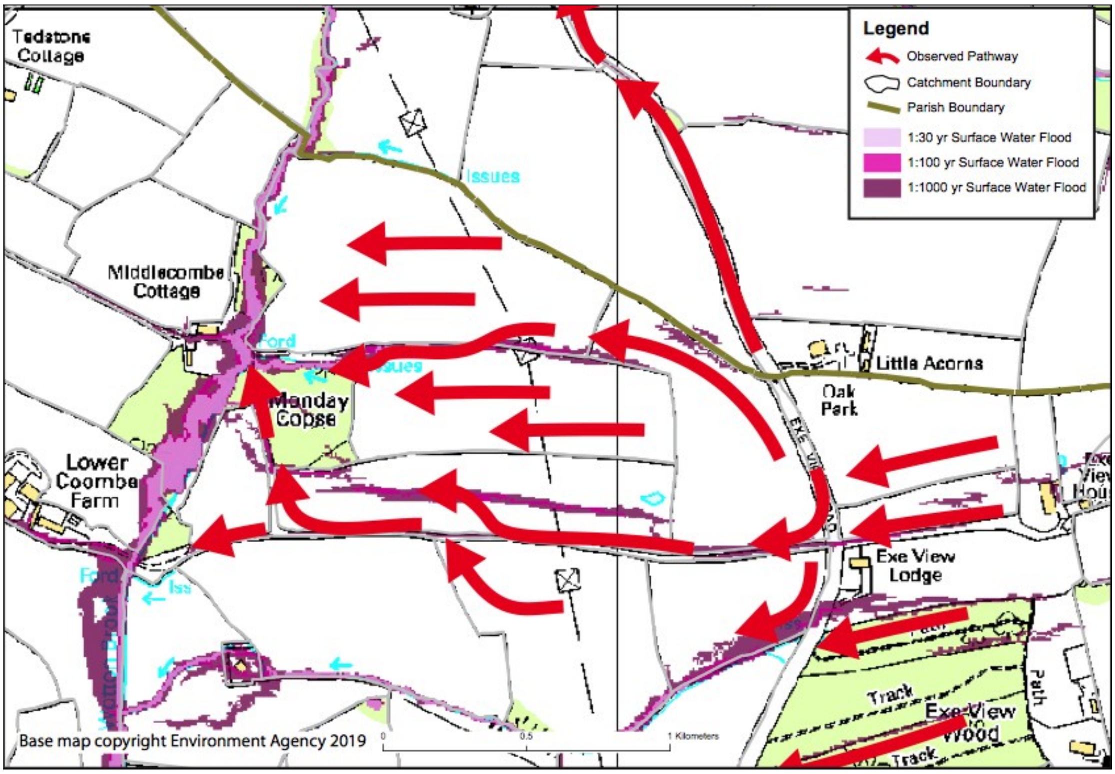


Photo 4 – Drainage from an access track on to Exe View Road

Here surface water from an access track drains towards Exe View Road and combines with flows from the highway. Some then enters a field with post harvest maize stubble.

Photo 5 – Ponding and runoff in maize stubble

The ponding of surface water in this post harvest maize field is made worse as a result of surface water runoff from Exe View Road. The photo shows flows draining along the wheelings.

Photo 6 – Runoff from maize fields west of Exe View Road

The runoff flows down the fields of maize stubble using a combination of routes (in wheelings, ditches and a track) to drain rapidly overland to the Wotton Brook near Monday Copse.

2.4 South catchment area (Map 6)

This area covers most of the section of the catchment to the east of Wotton Farm. Much of the land was retained as grassland in 2018, with small areas of arable.

The observations showed that surface water flows down Hulham Road and Wotton Lane, and these contribute to the stream entering the Wotton Brook below Wotton Farm and across grassland north of Summerfield House (Photo 7). Both of these pathways are important, with Hulham Road bringing some additional flows into the catchment and speeding up the response to precipitation.

In addition, observations showed that surface water flows down the fields parallel to Hulham Road, down the highway out of Exe View Wood, down the highway to the west of Wotton Bridge, and from the land to the south of Wotton House into the Wotton Lane drainage ditch which is frequently overloaded.

Map 6 – Observed pathways in south catchment area

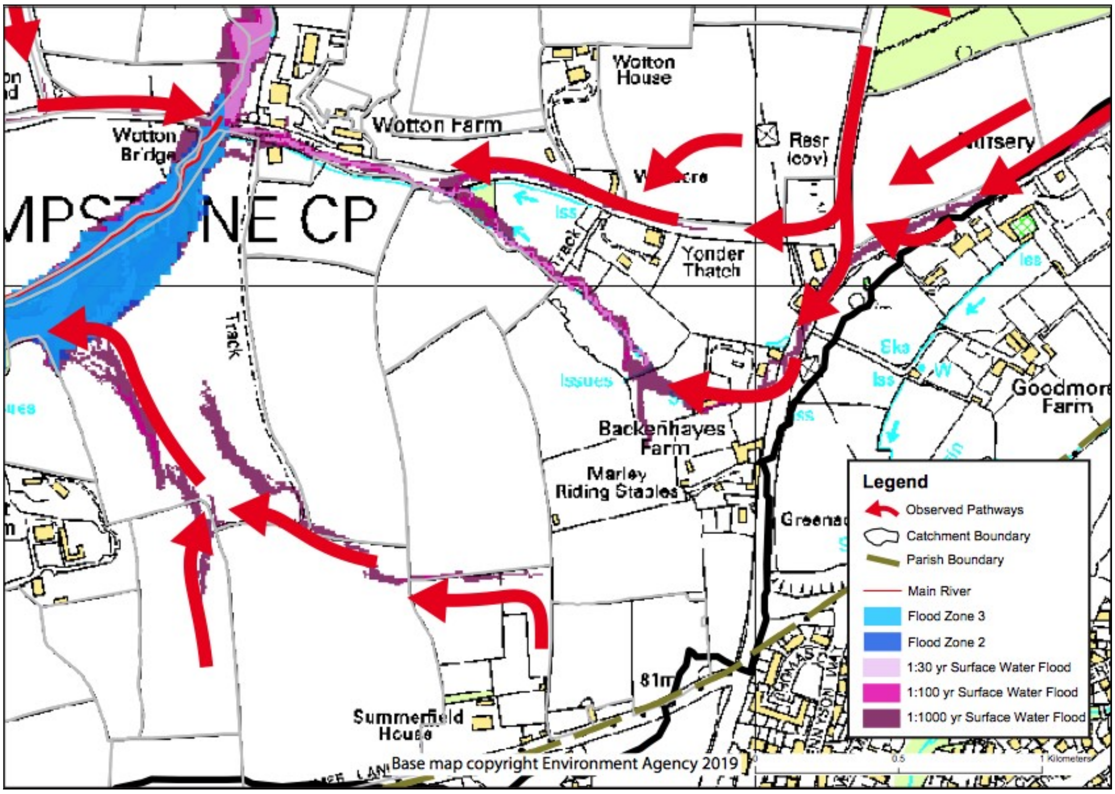


Photo 7 – Runoff over grassland north of Summerfield House

Overland surface water flow results in an intermittent watercourse across the grassland in fields to the north of Summerfield House. This drains to the Brook below Wotton Bridge.

Photo 8 – Runoff from field to Exe View Road

Here a significant flow of surface water leaves the gateway of a grassland field on the corner of Exe View Road. The complex drainage at the intersection of Hulham Road, Exe View Road and Wotton Lane means there is water arriving from several directions.

Photo 9 – Roadside ditch on Wotton Lane above Wotton Bridge

Separate streams of surface water, including runoff from Hulham Road, Wotton Lane and various fields, come together in this roadside ditch on Wotton Lane. The ditch often overflows and floods into the highway. Frequent flooding of the external areas of the adjacent property has also been reported.

2.5 West catchment area (Map 7)

This area is largely grassland and is drained by a west bank tributary of the Wotton Brook (Harefield Stream). It includes areas with long histories of flooding on the strategically important A376 highway (Exmouth to Exeter) to the north east of Lympstone village and the lower reaches of the Harefield Stream.

The Environment Agency flood map predicts surface water flows down the main highway adjacent to both the Wotton Brook and Harefield Stream crossings, and from land to the north-east of Thorn Farm. Observation and discussion with land managers and other local residents confirmed this, but also indicated an increased frequency of flooding in this area with the culvert in the farmyard often having insufficient capacity to carry Harefield Stream flows.

Map 7 – Observed pathways in west catchment area

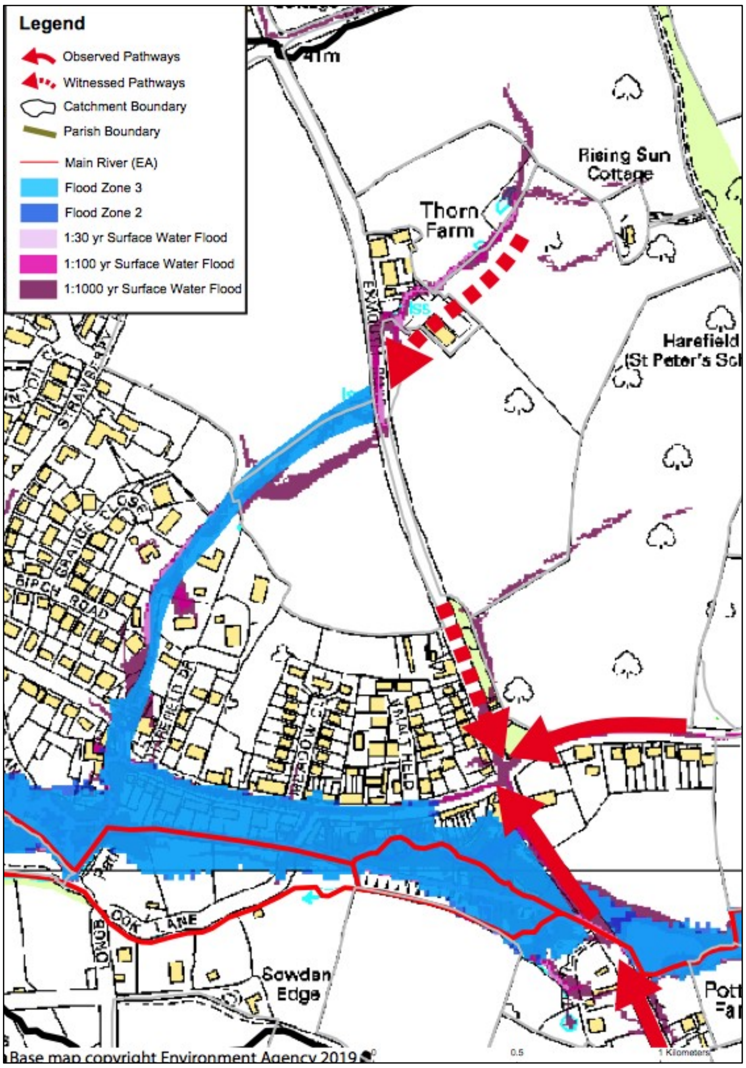


Photo 10 – Flooding on Longmeadow Road

Immediately below the intersection of the A376 and Wotton Lane, Longmeadow Road is reported to flood regularly during heavy and prolonged rainfall events.

Note: This photograph is from an earlier flooding incident, and has been provided by Lympstone Flood Resilience Group.

Photo 11 – Surface water lower down Longmeadow Road

It has been reported that vehicles often have to negotiate considerable surface water runoff on the highway.

Note: This photograph is from an earlier flooding incident, and has been provided by Lympstone Flood Resilience Group.

3 KEY CONTRIBUTING FACTORS

3.1 Overview

During Phase 1 of this study (in 2018) several issues were identified that could be contributing to the flood risk in Lympstone. These relate to:

- Farming practices that can damage the soil structure
- Highway and track drainage
- Potential runoff from the solar farm in the north east of the catchment.

Each of these issues was explored during Phase 2, and the observations are presented in 3.2 to 3.4, respectively. In summary, it is clear that all of the issues contribute to the overall flood risk, although the contribution of the solar farm is less certain and will be further investigated during Phase 3.

3.2 Farming practices and the impact on soil

Maize and other arable cropping

Maize is recognised as a high risk crop for soil damage and runoff due to the inevitability of late harvests. Field operations can result in serious damage to soil structure and water storage capacity, and there was evidence of this during our observations in Phase 2 (see photos below). However, the area of maize in the upper catchment (40 acres in 2018) has been reduced significantly in 2019. In the long-term, this will help reduce the flood risk, but in the short-term there will be periods of increased risk when other crops are being established.

The risks associated with other crops are lower than maize, but any cultivation is susceptible to the weather if the conditions change for the worse before the crop has been able to establish sufficient green cover to protect the soil.

Photo 12 – Runoff from maize stubbles

The surface water runoff leaving through this gateway is generated because infiltration into the soil has been affected by compaction in parts of the field. As a result, the rainwater flows across the surface, joins other flows and builds up energy, causing soil erosion and leaching of nutrients from the soils, before running onto the highway.

Photo 13 – View showing surface water runoff on maize stubbles

This shows the large areas of exposed soil in post-harvest maize stubbles. The surface water runoff is concentrated in wheelings and natural depressions down the fields towards the Wotton Brook.

Photo 14 – Example of degraded soil in maize

Soil in the maize headlands and close to gateways (with heavy traffic) is often compacted and has much reduced infiltration. This results in the surface becoming saturated and leads to rapid runoff. The deeper soil is relatively dry and, if the structure had been improved, could have accepted more rainfall before runoff would occur.

Photo 15 – Soil capping in a maize field

Although this soil shows better sub-surface soil structure, the lack of crop cover has led to some capping of the surface. The soil structure below could easily accept greater quantities of water but the capping will limit the soil's full capability.

Photo 16 – Tramlines in arable field

The tramlines in this field run down the slope which allows a quicker passage of water to the bottom of the field.

Tramlines are often first created when the soil has higher moisture levels, which leads to compaction. This inhibits water infiltration and the channels increase the speed of overland flow.

Livestock grazing and other grassland operations

The upper catchment is largely grassland. While this can be a low risk land use, compacted grassland is a problem throughout the South West. Management practices have changed over the years and the move towards more silage and over-winter grazing has increased the chances of soil damage.

Observations during Phase 2 identified considerable intermittent flows over grassland. There was some indication that this runoff is caused by a combination of degraded soil structure, livestock poaching, spring flows, and drainage from tracks and highways. This is illustrated by the photos below.

Photo 17 – Runoff across grassland

Looking south east from Tedstone Lane, this indicates significant overland flow below the ridge in a predominantly grassland section of the Wotton Brook catchment. A considerable proportion of the flow emanates from a spring system that sits just below the skyline.

Photo 18 – Runoff from grassland creating a gully

Here runoff from grassland has created a sizable gully where it enters the watercourse. The erosion shown suggests that the overland flow has considerable speed and force at times.

Photo 19 – Runoff from a grass reseed pouring though the hedge

Runoff from a grass reseed has found its way through a hedge and is using the track as a conduit to the Wotton Brook below.

Photo 20 – A spring emanating below the ridge north of Summer Lane

This photo shows one of the springs in the grassland area below the ridge north of Summer Lane. Observations suggest the flows are augmented by runoff from other sources during rainfall events.

3.3 Highway and track drainage

Highways and tracks generate their own surface water runoff and also often act as pathways for surface water from other sources. The overall significance is that runoff is channelled more rapidly to the watercourses with a potential to increase peak flows.

Photo 21 – Overspill from ditches to Exe View Road

The roadside ditches on Exe View Road often fill up and spill onto the road, contributing to highway flooding and the total quantity and rate of runoff. If managed well, the ditches could act as useful temporary storage and help reduce the rate of runoff (see Section 4.3).

Photo 22 – Run-off from woodland down track

Here drainage from the woodland at the headwaters of the Wotton Brook flows down a track onto Stoney Lane and re-enters the drainage system. It is then thrown out again when flows become too great for the pipe network or become blocked with debris.

Photo 23 – Runoff from a maize field onto bridleway

The runoff of surface water from an arable field runs through a hedge and takes the easiest route onto a bridleway. This transfers the flow more rapidly down to the Wotton Brook with potential to increase peak flows.

Photo 24 – Runoff from a highway to grassland

This is an example of surface water runoff from a highway (arising from several sources). It follows the slope and is directed into a grass field. If this were an arable field, the impact would be more serious. Nevertheless, it forms an intermittent watercourse and this speeds up the route of the runoff to the Wotton Brook.

Photo 25 – Highway channelling runoff

This highway is channelling surface water runoff from fields and ditches increasing its rate of flow so that there is potential for more rapid transfer to a watercourse. This is a common theme with the highways providing an unintended acceleration of flows along pathways to the Wotton Brook.

Photo 26 – Track runoff causing impact on arable field

Surface water runoff from a track is diverted into a post-harvest arable maize field. The flow of water cuts rills into the soil giving an ever easier route through the field. Such erosion can also result in severe soil and nutrient loss and pollution of watercourses

3.4 Solar farm

The 40 acre solar farm in the north east of the catchment has a large area of photovoltaic panels. Some of these panels are downslope and, therefore, there is potential for rapid surface water runoff increasing peak flows in the Wotton Brook. Observations below the site showed surface water crossing the grassland but this appears to be from a combination of subsurface drainage and ditches. There was no evidence of enhanced flows from the PV panels. The long dry summer of 2018 is likely to have improved soil conditions, and the good vegetation cover and limited trafficking would encourage rainfall infiltration. However, this is yet to be verified. Access to the PV area was not possible during Phase 2 but is being sought as part of Phase 3.

Photo 27 – Surface water on grassland below the solar PV panels

Observations showed a significant volume of water flooding the Exe View Road between Coombe Farm and Stony Lane. Much of the water was emanating from field ditches, together with water rising to the surface along the lower boundary of the solar PV field.

Photo 28 – Upwelling of subsurface flows

Inspection of the area below the solar PV site revealed upwelling of subsurface flows – possibly from the site drainage. There were no obvious signs of overland flows.

Photo 29 – Newly planted hedges at solar farm

Hedges have been planted along some of the solar farm boundaries. There is evidence from elsewhere that these can improve catchment hydrology by interrupting overland flows and allowing water infiltration to a greater depth. They can also create new habitats.

4 POSSIBLE INTERVENTIONS

4.1 Overview

Several possible NFM interventions in the upper Wotton Brook catchment have emerged during this study. These primarily relate to:

- Soil management
- Temporary storage of surface water
- Drainage management.

Each of the above is discussed in more detail in Sections 4.2 to 4.4 below. Many are relatively straightforward; some will require funding (potentially through environmental stewardship schemes and/or other sources); and some may require permits. All of them will need the buy-in of landowners/managers and other relevant stakeholders to be effective. Importantly, completion of the soil survey (Phase 3 of this study) and the hydraulic model are needed to confirm the required scale and cost-benefits of the interventions. Following this, the development of a strategic plan, in consultation with landowners/managers and other stakeholders, is recommended (see Section 6).

4.2 Soil management

Soils and soil management have a major influence on catchment hydrology, and this is now recognised under the Government's new policy framework for agriculture. Soils vary in their inherent ability to absorb water and aid infiltration. Some soils are especially vulnerable to land management practices that degrade the soil structure, and this increases the rate of surface water runoff. This is an area that can be managed and can be a classic 'win-win' – bringing business benefits to land managers and reducing flood risk.

Based on our observations during Phase 2 of this study, there is some evidence that degraded soil structure, including capping and compaction, is enhancing surface water runoff in some areas (see Photos 14 and 15 in Section 3.2). However, the full extent of soil structural degradation in the upper catchment is not yet known. This is the purpose of the soil survey to be completed in late 2019 (Phase 3 of the study).

In the meantime, it is worth considering possible interventions that might be used to limit the impact of field operations on the soil, improve soil structure, and minimise runoff. These include:

- Avoiding field operations when soils are wet.
- Following the contours during field operations.
- Controlling trafficking to minimise areas of soil damage, e.g., near gateways.
- Using cover crops to protect soils and capture nutrients.
- Avoiding grassland poaching and compaction by stock, or during silage-making.
- Using remedial operations such as sub-soiling (e.g., of arable tramlines) and aeration of degraded grassland soils.
- Using strips of contour ploughing or rough vegetation to reduce runoff.

4.3 Temporary storage of surface water

The observations during Phase 2 indicate that there are several opportunities to store surface water temporarily in the upper catchment - slowing down the flow of water to the Wotton Brook. These include:

- Managing woodland
- Developing areas of rough vegetation or wetlands, and planting hedges
- Developing swales in permanent grassland
- Creating detention ponds.

Each of these is discussed briefly below.

Managing woodland

The observations show that there are significant flows of surface water through woodland in the catchment (much of it from the surrounding land). Woodland often has the capacity to absorb large quantities of water due to the deep rooting and undisturbed soils so there is potential to use it to reduce the rate of runoff.

Photo 30 - Drainage through Monday Copse

In this area of woodland (in the middle of the upper catchment) the surface water flow is running straight through a channel in the vegetation. Work could be done to enhance the infiltration of water into the soil and slow the surface water flow.

There may also be potential to increase the area of woodland providing a moderating effect on surface water flows. This could provide other environmental benefits, including carbon sequestration, which may more easily attract funding in the future.

Developing areas of vegetation

Areas of thick vegetation in fields, e.g., tussocks of grass and rushes, small wetlands and hedges, have the potential to slow surface water runoff. These areas usually have good soil structure which encourages infiltration or physical detention – so providing short term delay to runoff. Observations show that many of these areas already exist in the upper catchment, and they could be further developed to reduce peak flows.

Photo 31 – Strip of rough vegetation at the bottom of a maize field

This shows an existing strip of rough vegetation at the bottom of a maize field. This helps to reduce runoff and also brings other environmental benefits, e.g., improving water quality and increasing habitat diversity.

Developing swales

A number or intermittent watercourses were observed crossing grassland as a result of drainage from the surrounding land and highways. There appears to be an opportunity to delay, and reduce, the flow to the Wotton Brook by using physical banks or swales to help to store these flows temporarily. In the flatter sections of the upper catchment there is also the opportunity to reconnect the Wotton Brook with some of its flood plain. This can hold significant quantities of water and slow the flow.

Photo 32 – Example of possible area for swales

This is an area where surface water runoff flows across grassland. The flows could be slowed by increasing storage using swales or banks.

Creating detention ponds

The principle of detention ponds is to allow surface water runoff to accumulate in small areas and then drain away at a slower rate to a watercourse. A number of apparently natural areas were observed in the catchment during this study (see Photos 33 and 34). Using excavated areas to store runoff could be a useful method of detaining flows that otherwise would rapidly increase stream flows. In some cases, relatively level roadside ditches could act as temporary storage areas providing they were regularly maintained. This would allow the water to drain away slowly rather than spilling into vulnerable fields or running down the highway as has been observed.

Photo 33 – Naturally formed pond containing highway runoff

This pond has developed naturally in a goyle as a result of highway runoff. It allows water to drain slowly. Its effectiveness could potentially be improved by intervention.

Photo 34 – Example of an existing detention pond

This pond is in an area within the water main drainage network. It is currently full of sediment, which both highlights previous erosion losses and the resulting reduction in capacity to temporarily store surface water runoff. There is an intervention opportunity here which illustrates the potential to create a more effective overall runoff storage system.

4.3 Drainage management

Drains play a significant part in catchment hydrology. They include drainage from highways, tracks, ditches and fields. If they are functioning well, they will transport water efficiently away from soils and infrastructure into the watercourse. For effective flood risk management, a balance is needed between ensuring such rapid drainage and managing peak flows in watercourses.

Based on observations made during Phase 2, a number of potential opportunities to reduce flood risk by changing drainage systems were identified, including:

- Ensuring highway drainage is operating effectively
- Maintaining ditches for initial storage of runoff
- Ensuring field drainage operates to provide early soil infiltration capacity for subsequent rainfall.

Each of these is discussed briefly below.

Ensuring highway drainage is operating effectively

Observations showed that the paved area of highways (and tracks) contributes to rapid response from rainfall. In some cases, it also acts to concentrate, accelerate and distribute runoff flows from various sources, including from outside the catchment. Often runoff from various sources simply follows the highway as a route of least resistance, spilling at random into fields or woodland and sometimes back to the highway again. Several areas of road flooding were noted where runoff was too much for the available drainage system.

Interventions may be possible to control the pathways and the speed of transfer of surface water by balancing the drainage routes and, where necessary, directing water into detention systems.

Photo 35 – Example of a highway ditch overflowing

This overflowing on to the highway (and into a field) may be due to lack of ditch maintenance or blocked highway drains. Ditches can provide some storage during intense rainfall events.

Ensuring field drainage operates effectively

Well drained fields have the capacity to absorb rainfall and pass some of this through its soil profile to the drainage below. If this process is not functioning, soils will generate surface water flows resulting in rapid runoff to the local watercourse. Well drained soils reduce the speed of water transfer and this can sometimes be the difference between the stream/river reaching critical flood level or remaining within its banks. Also, well drained land will continue to drain after the rainfall stops and create more capacity within the soil for future rainfall events.

Photo 36 – Blocked field drains causing surface water runoff

In this post-harvest maize field, it appears the field drains have become impeded and the water has been forced back to the surface where it runs over the soil following the down slope towards the nearest drainage channel. Intervention to improve the drainage could reduce the speed of runoff.

5 CONCLUSIONS

Building on the positive engagement with land managers in the upper Wotton Brook catchment during Phase 1 of this study, the observations made during Phase 2 have provided valuable information on the surface water runoff pathways, the key contributing factors, and potential NFM interventions. However, it is important to remember that this has been a qualitative study. The information has been gained through visual observations made during just four significant rainfall events in the winter 2018/19. Moreover, the winter of 2018/19 was relatively benign and followed a dry summer.

Importantly, the information gained during Phase 2 will help ground-truth the hydraulic model currently being developed by the Environment Agency. Phase 3 of the study - the planned soil survey - will provide more quantitative data for the model. The hydraulic model should then provide a more accurate assessment of the contribution of the runoff from the upper catchment to the flood risk in Lympstone (both now and in the future). This is vital in order to plan interventions that are cost-effective and sustainable.

Section 2 of this report highlights the importance of ground-truthing and the addition of local data to the hydraulic model. The maps in 2.2 to 2.5 show that although the observed runoff pathways generally reflect the Environment Agency's existing flood map for the catchment, the existing map underestimates the runoff from agricultural land, highways and tracks, and most likely the frequency of flooding. On the latter point, the extent of runoff observed was surprising considering it was a relatively benign winter.

The observations of runoff pathways also highlight the wide ranging impact of surface water flooding, not only in Lympstone but also to highways and land in Woodbury Parish. Certain highways, such as Exe View Road and the A376, carry considerable flood water and can be impassable at times during prolonged heavy rainfall. Inter-catchment transfer was also observed on the highway network e.g. on Hulham Road and Stoney Lane which bring extra runoff rapidly into the Wotton Brook catchment.

Further investigation of the issues that could be contributing to runoff also proved very useful. The observations, discussed in Section 3, show that the increased runoff from arable land (particularly maize fields), and some grassland, is most likely due to soil damage (compaction and capping), while highways and tracks collect runoff from various sources and distribute it rapidly to watercourses and across land. However, the contribution of the solar farm is still not certain. Full access to the solar farm was not possible during Phase 2 but is being sought for Phase 3. Observations below the site showed no direct overland flows, but there is an intermittent watercourse that appears to be fed by springs or subsurface drainage.

Overall, the observations during Phase 2 highlight several potential NFM interventions, relating to soil management, temporary storage of surface water, and drainage management. These are discussed in Section 4. However, completion of the soil survey (Phase 3) and the hydraulic model are needed to confirm the scale of interventions required, and their cost-effectiveness. Consultation and agreement with landowners/managers and other relevant stakeholders are also essential. The recommended approach is presented in Section 6.

6 RECOMMENDATIONS

Based on the findings and conclusions of Phase 2 of this study, the following steps are recommended:

1. Disseminate and discuss this report with key stakeholders, including landowners and tenants, members of the Project Steering Group, members of Lympstone and Woodbury Parish Councils, and the Environment Agency's hydraulic modelling team.

2. Consult with the Environment Agency's hydraulic modelling team to confirm the exact data required - particularly from the Phase 3 soil survey - to enhance the model.

3. Confirm the Phase 3 soil survey design and approach in consultation with stakeholders, including landowners and tenants.

4. Complete the soil survey as planned.

5. Ensure data from the soil survey is provided to the hydraulic modelling team in the format required.

6. Consult with the hydraulic modelling team on the baseline model results and the potential NFM interventions to be tested by the model.

7. Following completion of the soil survey and the hydraulic model (expected by the end of 2020), review potential NFM interventions and develop a strategic plan in consultation with stakeholders.